

Science

Introduction

Purpose of study

A high-quality science education provides the foundations for understanding the world through the specific disciplines of biology, chemistry and physics. Science has changed our lives and is vital to the world's future prosperity, and all pupils should be taught essential aspects of the knowledge, methods, processes and uses of science. Through building up a body of key foundational knowledge and concepts, pupils should be encouraged to recognise the power of rational explanation and develop a sense of excitement and curiosity about natural phenomena. They should be encouraged to understand how key foundational knowledge and concepts can be used to explain what is occurring, predict how things will behave, and analyse causes. This foundational understanding should be consolidated through their appreciation of the specific applications of science in society and the economy.

Aims

The National Curriculum for science aims to ensure that all pupils:

- develop **scientific knowledge and conceptual understanding** through the specific disciplines of biology, chemistry and physics
- develop understanding of the **nature, processes and methods of science** through different types of science enquiries that help them to answer scientific questions about the world around them
- are equipped with the scientific knowledge required to understand the **uses and implications** of science, today and for the future.

Scientific knowledge and conceptual understanding

The programmes of study describe a sequence of knowledge and concepts. While it is important that pupils make progress, it is also vitally important that they develop secure understanding of each key block of knowledge and concepts in order to progress to the next stage. Insecure, superficial understanding will not allow genuine progression: pupils may struggle at key points of transition (such as between primary and secondary school), build up serious misconceptions, and/or have significant difficulties in understanding higher-order content.

Pupils should be able to describe associated processes and key characteristics in common language, but they should also be familiar with, and use, technical terminology accurately and precisely. They should build up an extended specialist vocabulary. They should also apply their mathematical knowledge to their understanding of science,

including collecting, presenting and analysing data. The social and economic implications of science are important but, generally, they are taught most appropriately within the wider school curriculum: teachers will wish to use different contexts to maximise their pupils' engagement and motivation in science.

The nature, processes and methods of science

'Working scientifically' specifies the understanding of the nature, processes and methods of science for each year group. It should not be taught as a separate strand. The notes and guidance give examples of how 'working scientifically' might be embedded within the content of biology, chemistry and physics, focusing on the key features of science enquiry, so that pupils learn to use a variety of approaches to answer relevant scientific questions. Science enquiry should include using the statistical cycle to seek answers to questions through collecting, analysing and presenting data. 'Working scientifically' will be developed further at Key Stages 3 and 4, once pupils have built up sufficient understanding of science to engage meaningfully in more sophisticated discussion of experimental design and control.

Spoken language

The National Curriculum for science reflects the importance of spoken language in pupils' development across the whole curriculum – cognitively, socially and linguistically. The quality and variety of language that pupils hear and speak are key factors in developing their scientific vocabulary and articulating scientific concepts clearly and precisely. They must be assisted in making their thinking clear, both to themselves and others, and teachers should ensure that pupils build secure foundations by using discussion to probe and remedy their misconceptions.

School curriculum

The programmes of study for science are set out year-by-year for Key Stages 1 and 2. Schools are, however, only required to teach the relevant programme of study by the end of the key stage. Within each key stage, schools therefore have the flexibility to introduce content earlier or later than set out in the programme of study. In addition, schools can introduce key stage content during an earlier key stage if appropriate. All schools are also required to set out their school curriculum for science on a year-by-year basis and make this information available online.

Attainment targets

By the end of each key stage, pupils are expected to know, apply and understand the matters, skills and processes specified in the relevant programme of study.

Key Stage 1

The principal focus of science teaching in Key Stage 1 is to enable pupils to experience and observe phenomena, looking more closely at the natural and humanly-constructed world around them. They should be encouraged to be curious and ask questions about what they notice. They should be helped to develop their understanding of scientific ideas by using different types of scientific enquiry to answer their own questions, including observing changes over a period of time, noticing patterns, grouping and classifying things, carrying out simple comparative tests and finding things out using secondary sources of information. They should begin to use simple scientific language to talk about what they have found out and communicate their ideas to a range of audiences in a variety of ways. Most of the learning about science should be done through the use of first-hand practical experiences, but there should also be some use of appropriate secondary sources, such as books, photographs and videos.

'Working scientifically' is described separately in the programme of study, but must **always** be taught through and clearly related to the teaching of substantive science content in the programme of study. Throughout the notes and guidance, examples show how scientific methods and skills might be linked to specific elements of the content.

Pupils should read and spell scientific vocabulary at a level consistent with their increasing word reading and spelling knowledge at Key Stage 1.

Working scientifically

Key Stage 1 programme of study (statutory requirements)	Notes and guidance (non-statutory)
<p>Working scientifically</p> <p>During Years 1 and 2, pupils should be taught to use the following practical scientific methods, processes and skills through the teaching of the programme of study content:</p> <ul style="list-style-type: none"> ▪ asking simple questions ▪ observing closely, using simple equipment ▪ performing simple tests ▪ identifying and classifying ▪ using their observations and ideas to suggest answers to questions ▪ gathering and recording data to help in answering questions (Year 2 only). 	<p>Working scientifically</p> <p>Pupils in Years 1 and 2 should use their science experiences to explore the world around them and use practical science to raise their own questions about how things are similar or different, how they change and how they happen; experience different ways of answering scientific questions; begin to work with different types of science enquiries, and begin to choose ways in which they might answer scientific questions. They should make comparisons between simple features of objects, materials and living things and, with help, decide how to sort and group them; observe changes over different periods of time and talk about what has happened. With guidance, they should begin to notice patterns and relationships. They should use simple measurements and equipment (e.g. hand lenses, egg timers) to gather data (Year 2 only); carry out simple tests; record simple data (Year 2 only) and talk about what they have found out. They should ask people questions and use simple secondary sources to find answers. With help, they should record and communicate their findings in a range of ways and begin to use simple scientific language.</p> <p>These opportunities for working scientifically should be provided across Years 1 and 2 so that the expectations in the programme of study can be met by the end of Year 2. Pupils are not</p>

	expected to cover each aspect for every area of study.
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Year 1

Year 1 programme of study (statutory requirements)	Notes and guidance (non-statutory)
<p>Plants</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> ▪ identify and name a variety of common plants, including garden plants, wild plants and trees, and those classified as deciduous and evergreen ▪ identify and describe the basic structure of a variety of common flowering plants, including roots, stem/trunk, leaves and flowers. 	<p>Plants</p> <p>Pupils should use the local environment throughout the year to study plants growing in their habitat. Where possible, they should observe the growth of flowers and vegetables that they have planted.</p> <p>They should become familiar with common names of flowers, examples of deciduous and evergreen trees, and plant structures (trees: trunk, roots, branches, leaves, fruit; garden and wild plants: flower, petals, stem, leaves, roots, fruit, bulb and seed).</p> <p>Pupils might work scientifically by: observing closely, perhaps using magnifying glasses, and comparing and contrasting familiar plants; describing how they were able to identify and group them, and drawing diagrams showing the parts of different plants and trees. Pupils might keep records of how plants have changed over time, for example the leaves falling off trees and buds opening; and compare and contrast how different plants change.</p>
<p>Animals, including humans</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> ▪ identify and name a variety of common animals that are 	<p>Animals, including humans</p> <p>Pupils should use the local environment throughout the year to study animals in their habitat. They should understand how to take care of animals taken from their local environment and the need to</p>

Year 1 programme of study (statutory requirements)	Notes and guidance (non-statutory)
<p>birds, fish, amphibians, reptiles, mammals and invertebrates</p> <ul style="list-style-type: none"> ▪ identify and name a variety of common animals that are carnivores, herbivores and omnivores ▪ describe and compare the structure of a variety of common animals (birds, fish, amphibians, reptiles, mammals and invertebrates, and including pets) ▪ identify, name, draw and label the basic parts of the human body and say which part of the body is associated with each sense. 	<p>return them safely after study. Pupils should become familiar with the common names of birds, fish, amphibians, reptiles, mammals and invertebrates, including pets.</p> <p>Pupils should have plenty of opportunities to learn the names of the main body parts (including head, neck, arms, elbows, legs, knees, face, ears, eyes, hair, mouth, teeth) through games, actions, songs and rhymes.</p> <p>Pupils might work scientifically by: using their observations to compare and contrast animals at first hand or through videos and photographs, describing how they identify and group them; grouping animals according to what they eat, and using their senses to compare different textures, sounds and smells.</p>
<p>Everyday materials</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> ▪ distinguish between an object and the material from which it is made ▪ identify and name a variety of everyday materials, including wood, plastic, glass, metal, water, and rock ▪ describe the simple physical properties of a variety of everyday materials ▪ compare and group together a variety of everyday materials 	<p>Everyday materials</p> <p>Pupils should explore, name and discuss everyday materials so that they become familiar with the names of materials and properties such as: hard/soft; stretchy/stiff; shiny/dull; rough/smooth; bendy/not bendy; waterproof/not waterproof; absorbent/not absorbent. Pupils should explore and experiment with a wide variety of materials, not only those listed in the programme of study, but including for example: brick, paper, fabrics, elastic, foil.</p>

Year 1 programme of study (statutory requirements)	Notes and guidance (non-statutory)
<p>on the basis of their simple physical properties</p> <ul style="list-style-type: none"> find out how the shapes of solid objects made from some materials can be changed by squashing, bending, twisting and stretching. 	<p>Pupils might find out about people who have developed useful new materials; for example, Dunlop, Macintosh or McAdam.</p> <p>Pupils might work scientifically by: performing simple tests to explore questions such as: 'What is the best material for an umbrella? ... for lining a dog basket? ... for curtains? ... for a bookshelf? ... for a gymnast's leotard?'</p>
<p>Seasonal changes</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> observe the apparent movement of the Sun during the day observe changes across the four seasons observe and describe weather associated with the seasons and how day length varies. 	<p>Seasonal changes</p> <p>Pupils should observe and talk about the weather, the seasons and how the Sun seems to move during the day.</p> <p>Pupils might work scientifically by: observing and recording the apparent movement of the Sun during the day, for example in a sequence of photographs or moving Teddy so he stays in the sunshine; making tables and charts about the weather and displays of what happens in the world around them, including day length, as the seasons change.</p>

Year 2

Year 2 programme of study (statutory requirements)	Notes and guidance (non-statutory)
<p>All living things</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> explore and compare the differences between things that are living, dead, and things that have never been alive. 	<p>All living things</p> <p>Pupils should be introduced to the idea that all living things have certain characteristics that are essential for keeping them alive and healthy. They should become familiar with the life processes that are common to all living things.</p> <p>Pupils might work scientifically by: sorting and classifying things according to whether they are living, dead or were never alive, and recording their findings using charts. They should describe how they knew where to place things, exploring questions such as: 'Is a flame alive? Is a deciduous tree dead in winter?' and talk about ways of answering their questions.</p>
<p>Plants</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> observe and describe how seeds and bulbs grow into mature plants find out and describe how plants need water, light and a suitable temperature to grow and stay healthy. 	<p>Plants</p> <p>Pupils should use the local environment throughout the year to observe how plants grow (including seeds, bulbs, fruit and vegetables, deciduous and evergreen bushes and trees). Pupils should be introduced to the requirements of plants for growth and survival, as well as the process of reproduction and growth in plants.</p> <p>Note: Seeds and bulbs need water to grow but do not need light;</p>

Year 2 programme of study (statutory requirements)	Notes and guidance (non-statutory)
	<p>seeds and bulbs have a store of food inside them.</p> <p>Pupils might work scientifically by: observing and recording, with some accuracy, the growth of a variety of plants as they change over time from a seed or bulb, or observing similar plants at different stages of growth; setting up a comparative test to show that plants need light and water to stay healthy.</p>
<p>Animals, including humans</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> ▪ notice that animals, including humans, have offspring which grow into adults ▪ find out about and describe the basic needs of animals, including humans, for survival (water, food and air) ▪ describe the importance for humans of exercise, eating the right amounts of different types of food, and hygiene. 	<p>Animals, including humans</p> <p>Pupils should be introduced to the basic needs of animals for survival, as well as the importance of exercise and nutrition for humans. They should also be introduced to the process of reproduction and growth in animals. The focus at this stage should be on helping pupils to recognise growth; they should not be expected to understand how reproduction occurs. The following examples might be used: egg, chick, chicken; egg, caterpillar, pupa, butterfly; spawn, tadpole, frog; lamb, sheep. Growing into adults can include reference to baby, toddler, child, teenager, adult.</p> <p>Pupils might work scientifically by: observing, through video or first-hand observation and measurement, how different animals, including humans, grow; asking questions about what things animals need for survival and what humans need to stay healthy; and suggesting ways to find answers to their questions.</p>

Year 2 programme of study (statutory requirements)	Notes and guidance (non-statutory)
<p>Habitats</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> ▪ identify that most living things live in habitats to which they are suited and describe how different habitats provide for the basic needs of different kinds of animals and plants, and how they depend on each other ▪ identify and name a variety of plants and animals in their habitats, including micro-habitats ▪ describe how animals obtain their food from plants and other animals, using the idea of a simple food chain, and identify and name different sources of food. 	<p>Habitats</p> <p>Pupils should be introduced to the terms 'habitat' (a natural environment or home of a variety of plants and animals) and 'micro-habitat' (a very small habitat, for example for woodlice under stones, logs or leaf litter). They should use the local environment to identify and study a variety of plants and animals within their habitat and observe how living things depend on each other, for example plants serving as a source of food and shelter for animals. Pupils should compare animals in familiar habitats with animals found in less familiar habitats, for example, on the seashore, in woodland, in the ocean, in the rainforest.</p> <p>Pupils might work scientifically by: constructing a simple food chain that includes humans (e.g. grass, cow, human); describing the conditions in different habitats and micro-habitats (under log, on stony path, under bushes); finding out how the conditions affect the number and type(s) of plants and animals that live there.</p>
<p>Uses of everyday materials</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> ▪ identify and compare the uses of a variety of everyday materials, including wood, metal, plastic, glass, brick/rock, and paper/cardboard. ▪ 	<p>Uses of everyday materials</p> <p>Pupils should identify and discuss the uses of different everyday materials so that they become familiar with how some materials are used for more than one thing (metal can be used for coins, cans, cars and table legs; wood can be used for matches, floors, and telegraph poles) or different materials are used for the same thing (spoons can be made from plastic, wood, metal, but not glass;</p>

Year 2 programme of study (statutory requirements)	Notes and guidance (non-statutory)
	<p>tables can be made from plastic, wood, metal, but not paper).</p> <p>Pupils might work scientifically by: comparing the uses of everyday materials in and around the school with materials found in other places (at home, the journey to school, on visits, and in stories, rhymes and songs); observing closely, identifying and classifying the uses of different materials, and recording their observations. Pupils should be encouraged to think about unusual and creative uses for everyday materials.</p>
<p>Movement</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> ▪ notice and describe how things are moving, using simple comparisons such as faster and slower ▪ compare how different things move. 	<p>Movement</p> <p>Pupils should observe closely some things moving. Pupils should discuss, describe and compare the movement of a variety of objects and, where appropriate, themselves, through actions such as sliding, rolling, falling, flying, walking and running. They can explore the movements through games, songs and rhymes, including work in physical education.</p> <p>Pupils might work scientifically by: asking questions about the movement of objects such as parachutes, toy cars and balloon rockets; comparing them, by measuring how far they go; ordering their findings and recording their observations and measurements, for example by constructing tables and charts, and drawing on their results to answer their questions.</p>

Lower Key Stage 2 – Years 3-4

The principal focus of science teaching in lower Key Stage 2 is to enable pupils to broaden their scientific view of the world around them. They should do this through exploring, talking about, testing and developing ideas about everyday phenomena and the relationships between living things and familiar environments, and by beginning to develop their ideas about functions, relationships and interactions. They should ask their own questions about what they observe and make some decisions about which types of scientific enquiry are likely to be the best ways of answering them, including observing changes over time, noticing patterns, grouping and classifying things, carrying out simple fair tests and finding things out using secondary sources of information. They should draw simple conclusions and use some scientific language, first, to talk about and, later, to write about what they have found out.

‘Working scientifically’ is described separately at the beginning of the programme of study, but must **always** be taught through and clearly related to substantive science content in the programme of study. Throughout the notes and guidance, examples show how scientific methods and skills might be linked to specific elements of the content.

Pupils should read and spell scientific vocabulary correctly and with confidence, using their growing word reading and spelling knowledge.

Working scientifically

Lower Key Stage 2 programme of study (statutory requirements)	Notes and guidance (non-statutory)
<p>Working scientifically</p> <p>During Years 3 and 4, pupils should be taught to use the following practical scientific methods, processes and skills through the teaching of the programme of study content:</p> <ul style="list-style-type: none"> ▪ asking relevant questions ▪ setting up simple practical enquiries, comparative and fair tests ▪ making accurate measurements using standard units, using a range of equipment, for example thermometers and data loggers ▪ gathering, recording, classifying and presenting data in a variety of ways to help in answering questions ▪ recording findings using simple scientific language, drawings, labelled diagrams, bar charts, and tables ▪ reporting on findings from enquiries, including oral and written explanations, displays or presentations of results and conclusions ▪ using results to draw simple conclusions and suggest improvements, new questions and predictions for setting up further tests 	<p>Working scientifically</p> <p>Pupils in Years 3 and 4 should use practical science to raise their own questions about the world around them. They should start to make their own decisions about the most appropriate type of science enquiry they might use to answer scientific questions; recognise when a simple fair test is necessary and help to decide about how to set it up; talk about criteria for grouping, sorting and classifying, and use simple keys. They should begin to identify where patterns might be found and what data to collect to identify them. They should help to make decisions about what observations to make, how long to make them for and the type of simple equipment that might be used. They should learn how to use new equipment, such as data loggers. They should collect data from their own observations and measurements, using notes, simple tables and standard units, and help to make decisions about how to record and analyse these data. With help, pupils should look for changes, patterns, similarities and differences in their data in order to draw simple conclusions and answer questions. With support, they should identify new questions arising from the data and find ways of improving what they have already done. They should also recognise when and how secondary sources might help</p>

<ul style="list-style-type: none"> ▪ identifying differences, similarities or changes related to simple scientific ideas and processes ▪ using straightforward scientific evidence to answer questions or to support their findings. 	<p>them to answer questions that cannot be answered through practical investigations. Pupils should use relevant scientific language to discuss their ideas and communicate their findings in ways that are appropriate for different audiences.</p> <p>These opportunities for working scientifically should be provided across Years 3 and 4 so that the expectations in the programme of study can be met by the end of Year 4. Pupils are not expected to cover each aspect for every area of study.</p>
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Year 3

Year 3 programme of study (statutory requirements)	Notes and guidance (non-statutory)
<p>Plants</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> ▪ identify and describe the functions of different parts of flowering plants: roots, stem, leaves and flowers ▪ explore the requirements of plants for life and growth (air, light, water, nutrients from soil, and room to grow) and how they vary from plant to plant ▪ investigate the way in which water is transported within plants ▪ explore the role of flowers in the life cycle of flowering plants, including pollination, seed formation and seed dispersal. 	<p>Plants</p> <p>Pupils should be introduced to the relationship between structure and function: the idea that every part has a job to do. This teaching should focus on the role of the roots and stem in nutrition and support, leaves for nutrition and flowers for reproduction.</p> <p>Note: Pupils can be introduced to the idea that plants can make their own food, but at this stage they do not need to understand how this happens.</p> <p>Pupils might work scientifically by: comparing the effect of different factors on plant growth, for example the amount of light, the amount of fertiliser; discovering how seeds are formed by observing the different stages of plant cycles over a period of time; looking for patterns in the structure of seeds that relate to how they are dispersed. They might observe how water is transported in plants, for example by putting cut, white carnations into coloured water and observing how water travels up the stem to the flowers.</p>

Year 3 programme of study (statutory requirements)	Notes and guidance (non-statutory)
<p>Animals, including humans</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> ▪ identify that animals, including humans, need the right types and amount of nutrition, and that they cannot make their own food; they get nutrition from what they eat ▪ describe the ways in which nutrients and water are transported within animals, including humans ▪ identify that humans and some animals have skeletons and muscles for support, protection and movement. 	<p>Animals, including humans</p> <p>Pupils should continue to learn about the importance of nutrition (including a balanced diet) and should be introduced to the main body parts associated with the skeletal and muscular system, finding out how different parts of the body have special functions.</p> <p>Pupils might work scientifically by: identifying and grouping animals with and without skeletons and observing and comparing their movement; exploring ideas about what would happen if humans did not have skeletons. They might compare and contrast the diets of different animals (including their pets) and decide ways of grouping them according to what they eat. They might research different food groups and how they keep us healthy and design meals based on what they find out.</p>
<p>Rocks</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> ▪ compare and group together different kinds of rocks on the basis of their simple physical properties ▪ relate the simple physical properties of some rocks to their formation (igneous or sedimentary) ▪ describe in simple terms how fossils are formed when things that have lived are trapped within sedimentary rock. 	<p>Rocks</p> <p>Linked with work in geography, pupils should explore different kinds of rocks and soils, including those in the local environment.</p> <p>Note: Pupils are not expected to be taught about the formation of metamorphic rocks, such as marble and slate.</p> <p>Pupils might work scientifically by: observing rocks, including those used in buildings and gravestones, and exploring how and why they might have changed over time; using a hand lens or</p>

Year 3 programme of study (statutory requirements)	Notes and guidance (non-statutory)
	<p>microscope to help them to identify and classify rocks according to whether they have grains or crystals, and whether they have fossils in them. Pupils might research and discuss the different kinds of living things whose fossils are found in sedimentary rock and explore how fossils are formed.</p>
<p>Light</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> ▪ observe and name a variety of sources of light, including electric lights, flames and the Sun, explaining that we see things because light travels from them to our eyes ▪ notice that light is reflected from surfaces ▪ associate shadows with a light source being blocked by something; find patterns that determine the size of shadows. 	<p>Light</p> <p>Pupils should explore materials to help them to understand the differences between the meaning of transparent, translucent and opaque. They should observe shadows being formed in everyday contexts, such as when they play outside or shine torches indoors.</p> <p>Note: Pupils should be warned that it is not safe to look directly at the Sun, even when wearing dark glasses.</p> <p>Pupils might work scientifically by: looking for patterns in what happens to shadows when the light source moves or the distance between the light source and the object changes; investigating the suitability of materials for different purposes, such as blackout curtains; exploring whether shiny things shine in the dark.</p>

Year 3 programme of study (statutory requirements)	Notes and guidance (non-statutory)
<p>Forces and magnets</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> ▪ notice that some forces need contact between two objects and some forces act at a distance ▪ observe how magnets attract or repel each other and attract some materials and not others ▪ compare and group together a variety of everyday materials on the basis of whether they are attracted to a magnet, and identify some magnetic materials. 	<p>Forces and magnets</p> <p>Pupils should observe that magnetic forces can be transmitted without direct contact, unlike most forces, where direct contact is necessary (for example, opening a door, pushing a swing).</p> <p>Note: Pupils do not need to be introduced to 'like' and 'unlike' magnetic poles until Year 5.</p> <p>Pupils might work scientifically by: investigating the strengths of different magnets and finding a fair way to compare them; sorting materials into those that are magnetic and those that are not.</p>

Year 4

Year 4 programme of study (statutory requirements)	Notes and guidance (non-statutory)
<p>All living things</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> ▪ identify and name a variety of living things (plants and animals) in the local and wider environment, using classification keys to assign them to groups ▪ give reasons for classifying plants and animals based on specific characteristics ▪ recognise that environments are constantly changing and that this can sometimes pose dangers to specific habitats. 	<p>All living things</p> <p>Pupils should use the local environment throughout the year to identify and study plants and animals in their habitat; and how the habitat changes throughout the year. Pupils should classify animals into the major groups such as: vertebrates (animals with backbones) into fish, amphibians, reptiles, birds, and mammals; invertebrates into snails and slugs, worms, spiders, and insects. Pupils should explore examples of human impact (both positive and negative) on environments such as the effect of population and development, litter or deforestation.</p> <p>Note: Plants are more difficult to classify, but can be grouped into categories such as trees, grasses, flowers, and non-flowering plants such as ferns and mosses.</p> <p>Pupils might find out about the significance of the work of scientists such as Carl Linnaeus, a pioneer of classification.</p> <p>Pupils might work scientifically by: exploring local small invertebrates and using guides or keys to identify them; making a guide to local living things; raising and answering questions based on their observations of animals and what they have found out about other animals that they have researched.</p>

Year 4 programme of study (statutory requirements)	Notes and guidance (non-statutory)
<p>Animals, including humans</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> describe the simple functions of the basic parts of the digestive system in humans identify the different types of teeth in humans and their simple functions. 	<p>Animals, including humans</p> <p>Pupils should be introduced to the main body parts associated with the digestive system, such as mouth, tongue, teeth, oesophagus, stomach and intestine and their special functions.</p> <p>Pupils might work scientifically by: comparing the teeth of carnivores and herbivores, and suggesting reasons for differences; finding out what damages teeth and how to look after them. They might draw and discuss their ideas about the digestive system and compare them with models or images.</p>
<p>Evolution and inheritance</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> identify how plants and animals, including humans, resemble their parents in many features recognise that living things have changed over time and that fossils provide information about living things that inhabited the Earth millions of years ago identify how animals and plants are suited to and adapt to their environment in different ways. 	<p>Evolution and inheritance</p> <p>Pupils should be introduced to the idea that characteristics are passed from parents to their offspring, for instance by exploring the family trees and family resemblances of historical personalities such as the Tudors or the Hapsburgs.</p> <p>Note: At this stage, pupils are not expected to understand how genes and chromosomes work.</p> <p>Building on the topic on rocks in Year 3, pupils should be reintroduced to fossils and find out, for example by studying dinosaurs, how things living on the Earth have changed over time. Pupils might find out about the work of palaeontologists such as Mary Anning.</p>

Year 4 programme of study (statutory requirements)	Notes and guidance (non-statutory)
	<p>Pupils might work scientifically by identifying, comparing and recording similarities and differences among themselves and other animals and looking for patterns; observing and raising questions about local animals and how they are adapted to their environment; finding out about how some other animals and plants, beyond their own locality, adapt to their environments.</p>
<p>States of matter</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> ▪ compare and group materials together, according to whether they are solids, liquids or gases ▪ observe that some materials change state when they are heated or cooled, and measure the temperature at which this happens in degrees Celsius (°C), building on their teaching in mathematics ▪ identify the part played by evaporation and condensation in the water cycle and associate the rate of evaporation with temperature. 	<p>States of matter</p> <p>Pupils should explore a variety of everyday materials and develop simple descriptions of the states of matter (solids can be held in your hands; liquids form a pool not a pile; gases escape from an unsealed container). Pupils should observe water as a solid, a liquid and a gas and should note the changes to water when it is heated or cooled.</p> <p>Note: Teachers should avoid using materials where heating is associated with chemical change, for example, through baking or burning.</p> <p>Pupils might work scientifically by: grouping and classifying a variety of different materials; exploring the effect of temperature on substances such as chocolate, butter, cream (for example, to make food such as biscuits and ice-cream for a party). They might observe and record evaporation over a period of time, such as a puddle in the playground or washing on a line, and investigate the effect of temperature on washing drying or snowmen melting.</p>

Year 4 programme of study (statutory requirements)	Notes and guidance (non-statutory)
<p>Sound</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> ▪ observe and name a variety of sources of sound, noticing that we hear with our ears ▪ identify how sounds are made, associating some of them with something vibrating ▪ recognise that sounds get fainter as the distance from the sound source increases ▪ find patterns between the pitch of a sound and features of the object that produced it ▪ find patterns between the volume of a sound and the strength of the vibrations that produced it. 	<p>Sound</p> <p>Linked with work in music, pupils should explore various ways of making sounds, for example using a range of musical instruments to make louder and softer, and higher and lower sounds.</p> <p>Pupils might work scientifically by: exploring how the pitch and volume of sounds can be changed in a variety of ways, and finding patterns in the data (for example, blowing across the top of bottles, changing the length and thickness of elastic bands). They might make ear muffs from a variety of different materials to investigate which provides the best insulation against sound.</p>

Year 4 programme of study (statutory requirements)	Notes and guidance (non-statutory)
<p>Electricity</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> ▪ identify common appliances that run on electricity ▪ construct a simple series electrical circuit ▪ identify whether or not a lamp will light in a simple series circuit based on whether or not the lamp is part of a complete loop with a battery ▪ recognise that a switch opens and closes a circuit and associate this with whether or not a lamp lights in a simple series circuit ▪ recognise some common conductors and insulators, and associate metals with being good conductors. 	<p>Electricity</p> <p>Pupils should construct simple series circuits, trying different components, such as bulbs, buzzers and motors, and including switches, and use their circuits to create simple devices. Pupils should draw the circuit as a pictorial representation, not necessarily using conventional circuit symbols at this stage; these will be introduced in Year 6.</p> <p>Note: Pupils might use the terms current and voltage, but these should not be introduced or defined formally at this stage. Pupils should be taught about precautions for working safely with electricity.</p> <p>Pupils might work scientifically by: observing patterns, for example that bulbs get brighter if more cells are added, that metals tend to be conductors of electricity, and that some materials can and some cannot be used to connect across a gap in a circuit.</p>

Upper Key Stage 2 – Years 5-6

The principal focus of science teaching in upper Key Stage 2 is to enable pupils to develop a deeper understanding of a wide range of scientific ideas. They should do this through exploring and talking about their ideas; asking their own questions about scientific phenomena; and analysing functions, relationships and interactions more systematically. At upper Key Stage 2, they should encounter more abstract ideas and begin to recognise how these ideas help them to understand and predict how the world operates. They should also begin to recognise that scientific ideas change and develop over time. They should select the most appropriate ways to answer science questions using different types of scientific enquiry, including observing changes over different periods of time, noticing patterns, grouping and classifying things, carrying out fair tests and finding things out using a wide range of secondary sources of information. Pupils should draw conclusions based on their data and observations, use evidence to justify their ideas, and use their scientific knowledge and understanding to explain their findings.

‘Working and thinking scientifically’ is described separately at the beginning of the programme of study, but must **always** be taught through and clearly related to substantive science content in the programme of study. Throughout the notes and guidance, examples show how scientific methods and skills might be linked to specific elements of the content.

Pupils should read, spell and pronounce scientific vocabulary correctly.

Working scientifically

Upper Key Stage 2 programme of study (statutory requirements)	Notes and guidance (non-statutory)
<p>Working scientifically</p> <p>During Years 5 and 6, pupils should be taught to use the following practical scientific methods, processes and skills through the teaching of the programme of study content:</p> <ul style="list-style-type: none"> ▪ planning enquiries, including recognising and controlling variables where necessary ▪ taking measurements, using a range of scientific equipment, with increasing accuracy and precision ▪ recording data and results of increasing complexity using scientific diagrams and labels, classification keys, tables, bar and line graphs, and models ▪ reporting findings from enquiries, including oral and written explanations of results, explanations involving causal relationships, and conclusions ▪ presenting findings in written form, displays and other presentations ▪ using test results to make predictions to set up further comparative and fair tests ▪ using simple models to describe scientific ideas ▪ identifying scientific evidence that has been used to support 	<p>Working scientifically</p> <p>Pupils in Years 5 and 6 should use their science experiences to: explore ideas and raise different kinds of questions; select and plan the most appropriate type of science enquiry to use to answer scientific questions; recognise when and how to set up fair tests and explain which variables need to be controlled and why. They should use and develop keys and other information records to identify, classify and describe living things and materials, and identify patterns that might be found in the natural environment. They should make their own decisions about what observations to make, what measurements to use and how long to make them for; choose the most appropriate equipment to make measurements and explain how to use it accurately. They should decide how to record data from a choice of familiar approaches; look for different causal relationships in their data and identify evidence that refutes or supports their ideas. They should use their results to identify when further comparative tests and observations might be needed; recognise which secondary sources will be most useful to research their ideas and begin to separate opinion from fact. They should use relevant scientific language and illustrations to discuss, communicate and justify their scientific ideas and should talk about how scientific ideas have developed over time.</p>

<p>or refute ideas or arguments.</p>	<p>These opportunities for working scientifically should be provided across Years 5 and 6 so that the expectations in the programme of study can be met by the end of Year 6. Pupils are not expected to cover each aspect for every area of study.</p>
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Year 5

Year 5 programme of study (statutory requirements)	Notes and guidance (non-statutory)
<p>All living things</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> describe the life cycles common to a variety of animals, including humans (birth, growth, development, reproduction, death), and to a variety of plants (growth, reproduction and death). 	<p>All living things</p> <p>Pupils should study their local environment throughout the year and observe life-cycle changes in a variety of living things, for example plants in the vegetable garden or flower border, and animals in the local environment. They should find out about the work of naturalists and animal behaviourists such as David Attenborough and Jane Goodall.</p> <p>Pupils might work scientifically by: observing and comparing the life cycles of plants and animals in their local environment with other plants and animals around the world (the rainforest, under the oceans, desert areas and in prehistoric times), asking pertinent questions and suggesting reasons for similarities and differences.</p>
<p>Animals, including humans</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> identify and name the main parts of the human circulatory system, and explain the functions of the heart, blood vessels and blood (including the pulse and clotting). 	<p>Animals, including humans</p> <p>Pupils should build on their learning from Years 3 and 4 about the main body parts and internal organs (skeletal, muscular and digestive system) to explore how the circulatory system enables the body to function.</p> <p>Pupils should find out how ideas about the circulatory system have changed through studying the work of scientists in the past, such as William Harvey, who described the circulatory system in the</p>

Year 5 programme of study (statutory requirements)	Notes and guidance (non-statutory)
	<p>seventeenth century, and Galen, the Roman physician of the second century.</p> <p>Pupils might work scientifically by: discussing and drawing what they think the circulatory system looks like and comparing this with images from other sources; discussing, drawing or creating models of how the main organs of the body fit together and function; comparing the effect of different types of activity on pulse rate and breathing rate. They might find out about the effects of things that might damage the body's systems. They might compare the organ systems of the human body with the organ systems of a variety of animals, asking pertinent questions and suggesting reasons for similarities and differences.</p>
<p>Properties of everyday materials and reversible change</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> compare and group together everyday materials based on evidence from comparative and fair tests, including their hardness, solubility, conductivity (electrical and thermal), and response to magnets understand how some materials will dissolve in liquid to form a solution, and describe how to recover a substance from a solution use knowledge of solids, liquids and gases to decide how mixtures might be separated, including through filtering, 	<p>Properties of everyday materials and reversible change</p> <p>Pupils should build a more systematic understanding of materials by exploring and comparing the properties of a broad range of materials and relating these to what they learnt about magnetism in Year 3 and about electricity in Year 4. They should experiment with reversible changes, including melting, dissolving, evaporating, filtering and sieving.</p> <p>Note: Pupils are not required to make quantitative measurements about conductivity and insulation at this stage. It is sufficient for them to observe that some conductors will produce a brighter bulb in a circuit than others and that some materials will feel hotter than</p>

Year 5 programme of study (statutory requirements)	Notes and guidance (non-statutory)
<p>sieving and evaporating</p> <ul style="list-style-type: none"> ▪ give reasons, based on evidence from comparative and fair tests, for the particular uses of everyday materials, including metals, wood and plastic ▪ demonstrate that dissolving, mixing and changes of state are reversible changes. 	<p>others when a heat source is placed against them.</p> <p>Pupils might work scientifically by: investigating questions such as 'Which materials would be the most effective for making a warm jacket, or for wrapping ice cream to stop it melting?' They might compare materials in order to make a switch in a circuit.</p>
<p>Earth and space</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> ▪ describe the movement of the Earth relative to the Sun in the solar system ▪ describe the movement of the Moon relative to the Earth ▪ describe the Sun, Earth and Moon as approximately spherical bodies ▪ use the idea of the Earth's rotation to explain day and night. 	<p>Earth and space</p> <p>Pupils should be introduced to a model of the Sun and Earth that allows the explanation of day and night. Pupils should learn that the Sun is a star at the centre of our solar system and that it has eight planets: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune (Pluto was reclassified as a 'dwarf planet' in 2006). They should understand that a moon is a celestial body that orbits a planet (Earth has one moon; Jupiter has four large moons and numerous smaller ones).</p> <p>Note: Pupils should be warned that it is not safe to look directly at the Sun, even when wearing dark glasses.</p> <p>Pupils should find out about the way that ideas about the solar system have developed by studying the work of scientists such as Ptolemy, Alhazen and Copernicus, understanding how the geocentric model of the solar system gave way to the heliocentric model.</p> <p>Pupils might work scientifically by: comparing the time of day at</p>

Year 5 programme of study (statutory requirements)	Notes and guidance (non-statutory)
	different places on the Earth through internet links and direct communication; creating simple models of the solar system; constructing simple shadow clocks and sundials, calibrated to show midday and the start and end of the school day; working out how places such as Stonehenge were used as astronomical clocks.
<p>Magnetism</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> ▪ describe magnets as having two poles ▪ predict whether two magnets will attract or repel each other, depending on which poles are facing. 	<p>Magnetism</p> <p>Pupils should be introduced to a predictive model for the way magnets behave. They should explore the behaviour and everyday uses of different magnets (for example, bar, ring, button and horseshoe) and find out about how the Earth acts as a magnet.</p> <p>Pupils might work scientifically by: looking for patterns in the way that magnets behave in relation to each other and what might affect this, such as the strength of the magnet or which pole faces another; identifying how these properties make magnets useful in everyday items and suggesting creative uses for different magnets. They might explore what happens if magnets are hung from threads or floated on water and relate this to the development and use of compasses for navigation.</p>

Year 6

Year 6 programme of study (statutory requirements)	Notes and guidance (non-statutory)
<p>All living things</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> ▪ explain the classification of living things into broad groups according to common observable characteristics and based on similarities and differences, including plants, animals and micro-organisms ▪ describe the life process of reproduction in some plants and animals ▪ describe the changes as humans develop from birth to old age ▪ recognise the impact of diet, exercise, drugs and lifestyle on the way their bodies function. 	<p>All living things</p> <p>Pupils should build on their learning about the classification of all living things in Year 4 by looking at the classification system in more detail. They should be introduced to the term 'kingdom' and learn that most scientists classify things into 'five kingdoms' (bacteria, protists, animals, plants and fungi). Through direct observations where possible, they should classify animals into vertebrates (reptiles, fish, amphibians, birds and mammals) and invertebrates. They should find out about different types of reproduction, including sexual and asexual reproduction in plants, and sexual reproduction in animals. Pupils should build on what they have learnt in previous years about how the various body systems function. Pupils should learn how to keep their bodies healthy and how their bodies might be damaged – including how some drugs and other substances can be harmful to the human body.</p> <p>Pupils might work scientifically by: devising classification systems and keys to identify some animals and plants in the immediate environment. Pupils might try to grow new plants from different parts of the parent plant, for example seeds, stem and root cuttings, tubers, bulbs. They might observe changes in an animal over a period of time (for example, by hatching and rearing chicks); comparing how different animals reproduce and grow; and</p>

Year 6 programme of study (statutory requirements)	Notes and guidance (non-statutory)
	<p>exploring the work of scientists and scientific research (including historical sources, e.g. the work of John Boyd Orr) about the relationship between diet, exercise, drugs, lifestyle and health. They might collect data by interviewing health professionals and create guidance for younger children about how bodies work and how to keep them healthy.</p>
<p>Evolution and inheritance</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> ▪ recognise that living things produce offspring of the same kind, but normally offspring vary and are not identical to their parents ▪ describe how adaptation leads to evolution ▪ recognise how and why the human skeleton has changed over time, since we separated from other primates. 	<p>Evolution and inheritance</p> <p>Building on what they have learnt about evolution and inheritance in Year 4, pupils should look in more detail at how living things evolve. They should be introduced to the idea that variation in offspring over time can make animals more or less able to survive in particular environments and lead to evolutionary change. Pupils might find out about Charles Darwin's work on evolution.</p> <p>Pupils might work scientifically by: comparing how some living things are adapted to survive in extreme conditions, for example cacti, penguins and camels. They might analyse the advantages and disadvantages of specific adaptations, such as being on two feet rather than four, having a long or a short beak, having gills or lungs, tendrils on climbing plants, brightly coloured and scented flowers.</p>

Year 6 programme of study (statutory requirements)	Notes and guidance (non-statutory)
<p>Changes that form new materials</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> ▪ explain that some changes result in the formation of new materials, and that this kind of change is not usually reversible, including changes associated with burning, oxidation, and the action of acid on bicarbonate of soda. 	<p>Changes that form new materials</p> <p>Building on their work in Year 5 about changes that are easily reversible, pupils should explore changes that are difficult to reverse, such as burning, rusting (oxidisation) and reactions, for example vinegar with bicarbonate of soda. They should find out about how chemists create new materials, for example Spencer Silver, who invented the glue for sticky notes or Ruth Benerito, who invented wrinkle-free cotton.</p> <p>Note: Safety guidelines should be followed when burning materials.</p> <p>Pupils might work scientifically by: observing and comparing the changes that take place, for example when burning different materials or baking bread or cakes. They might research and discuss how chemical changes have an impact on our lives, for example cooking, and discuss the creative use of new materials such as polymers, super-sticky and super-thin materials.</p>
<p>Light</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> ▪ understand that light appears to travel in straight lines ▪ use the idea that light travels in straight lines to explain that objects are seen because they give out or reflect light into 	<p>Light</p> <p>Pupils should explore the way that light behaves, including light sources, reflection and refraction. They should talk about what happens and make predictions. They should experience a range of examples of interesting aspects of light such as rainbows, colours on soap bubbles, objects looking bent in water and white light</p>

Year 6 programme of study (statutory requirements)	Notes and guidance (non-statutory)
<p>the eye</p> <ul style="list-style-type: none"> ▪ use the idea that light travels in straight lines to explain why shadows have the same shape as the objects that cast them, and to predict the size of shadows when the position of the light source changes. 	<p>being split by prisms.</p> <p>Pupils might work scientifically by: deciding where to place rear-view mirrors on cars; designing and making a periscope and using the idea that light appears to travel in straight lines to explain how it works. They might investigate the relationship between light sources, objects and shadows by using shadow puppets.</p>
<p>Forces</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> ▪ explain that unsupported objects fall towards the Earth because of the force of gravity acting between the Earth and the falling object ▪ identify the effect of drag forces, such as air resistance, water resistance and friction, that act between moving surfaces ▪ describe, in terms of drag forces, why moving objects that are not driven tend to slow down ▪ understand that force and motion can be transferred through mechanical devices such as gears, pulleys, levers and springs. 	<p>Forces</p> <p>Pupils should explore falling objects and the effects of air resistance. They should experience forces that make things begin to move, get faster or slow down. Pupils should explore the effects of friction on movement and find out how it slows or stops moving objects, for example by observing the effects of a brake on a bicycle wheel. They should explore the effects of air resistance by observing how different objects such as parachutes and sycamore seeds fall. Pupils should explore the effects of levers, pulleys and simple machines on movement. Pupils might find out how scientists such as Galileo and Isaac Newton helped to develop the theory of gravitation.</p> <p>Pupils might work scientifically by: designing and making a variety of parachutes and carrying out fair tests to determine which designs are the most effective. They might explore resistance in water by making and testing boats of different shapes. They might design and make a simple lever and explore its effects.</p>

Year 6 programme of study (statutory requirements)	Notes and guidance (non-statutory)
<p>Electricity</p> <p>Pupils should be taught to:</p> <ul style="list-style-type: none"> ▪ identify and name the basic parts of a simple electrical circuit, including cells, wires, bulbs, switches and buzzers ▪ associate the brightness of a lamp or the volume of a buzzer with the number and voltage of cells used in the circuit ▪ compare and give reasons for variations in how components function, including the brightness of bulbs, the loudness of buzzers and the on/off position of switches. 	<p>Electricity</p> <p>Building on their work in Year 4, pupils should construct simple series circuits, trying different components, such as switches, bulbs, buzzers and motors. They should learn how to represent a simple circuit in a diagram using recognised symbols.</p> <p>Note: Pupils are expected to learn only about series circuits, not parallel circuits. Pupils should be taught to take the necessary precautions for working safely with electricity.</p> <p>Pupils might work scientifically by: systematically identifying the effect of changing one component at a time in a circuit; designing and making a set of traffic lights, a burglar alarm or some other useful circuit.</p>

Key Stage 3

Working scientifically

Through the content across all three disciplines, pupils should be taught to:

Experimental skills and investigations

- ask questions and develop a line of enquiry based on observations of the real world, alongside prior knowledge and experience
- make predictions using scientific knowledge and understanding
- plan and design investigations and experiments to make observations and to test predictions, including identifying independent, dependent and control variables and their intrinsic nature and other factors to be taken into account when collecting evidence and data
- use appropriate techniques, apparatus, and materials during fieldwork and laboratory work, paying attention to health and safety
- make and record observations and measurements using a range of methods for different investigations; and evaluate the reliability of methods and suggest possible improvements

Handling information and problem solving

- present observations and data using appropriate methods, including tables and graphs
- interpret observations and data, including identifying patterns and using observations, measurements and data to draw conclusions
- present reasoned explanations, including explaining data in relation to predictions and hypotheses
- evaluate data, showing awareness of potential sources of random and systematic error
- identify further questions arising from their results

Scientific attitudes

- pay attention to objectivity and concern for validity, accuracy, precision and measurement of uncertainty
- understand that scientific methods and theories develop as scientists modify earlier explanations to take account of new evidence and ideas, together with the importance of publishing results and peer review
- evaluate risks

Measurement

- understand and use SI units and IUPAC (International Union of Pure and Applied Chemistry) chemical nomenclature
- use and derive simple equations
- undertake basic data analysis.

Subject content

Biology

Structure and function of living organisms

Pupils should be taught about:

Cells and organisation

- cells as the fundamental unit of living organisms, including how to observe and record cell structure using a light microscope
- the functions of the cell wall, cell membrane, cytoplasm, nucleus, vacuole, mitochondria and chloroplasts
- the similarities and differences between plant and animal cells
- the role of diffusion in the movement of materials in and between cells
- the structure of Amoeba and Euglena
- the hierarchical organisation of multicellular organisms: from cells to tissues to organs to systems to organisms

The skeletal and muscular systems

- the structure and functions of the human skeleton, to include support, protection, movement and making blood cells
- biomechanics – the interaction between skeleton and muscles, including the measurement of force exerted by different muscles
- the function and antagonistic actions of major muscle groups

Human nutrition and digestion

- content in a healthy human diet: carbohydrates, fats, proteins, vitamins, minerals, dietary fibre and water, and why each is needed
- simple food tests for starch, simple (reducing) sugars, protein, fat
- calculations of energy requirements in a healthy daily diet
- the consequences of imbalances in the diet, including obesity, starvation and deficiency diseases
- the tissues and organs of the digestive system, including adaptations to function and how the digestive system digests food (enzymes simply as biological catalysts)
- the importance of bacteria in the digestive system

The breathing (gas exchange) system

- the structure and functions of the gas exchange system in humans, including adaptations to function
- the mechanism of breathing to move air in and out of the lungs, using a pressure model to explain the movement of gases, including simple measurements of lung volume
- the impact of exercise, asthma and smoking on the breathing system

Health

- the effects of drugs (including as medicines as well as substance misuse) on behaviour, health and life processes such as conception, growth and development.

Energy flow and material cycles

Pupils should be taught about:

Photosynthesis

- the dependence of almost all life on Earth on the transfer of solar energy to plants and algae in photosynthesis
- the relationship between the structures and functions of leaves, including chloroplasts and stomata
- reactants in, and products of, photosynthesis, and the word equation for photosynthesis
- mineral nutrition in plants, to explain the role of nitrates
- chemosynthesis in bacteria and other organisms

Cellular respiration

- aerobic and anaerobic respiration in living organisms, including the breakdown of organic molecules to enable all the other chemical processes necessary for life
- the word equation for aerobic respiration
- the process of anaerobic respiration in humans and micro-organisms, including fermentation, and the word equation for anaerobic respiration
- the differences between aerobic and anaerobic respiration.

Interactions and interdependencies

Pupils should be taught about:

Relationships in an ecosystem

- the interdependence of organisms, including food webs and the accumulation of toxic materials

- how organisms affect, and are affected by, their environment
- niches and the role of variation in enabling closely-related living things to survive in the same ecosystem.

Genetics and evolution

Pupils should be taught about:

Reproduction

- reproduction in humans (as an example of a mammal), including the structure and function of the male and female reproductive systems, menstrual cycle (without details of hormones), gametes, fertilisation, gestation and birth, to include the effect of maternal lifestyle on the foetus through the placenta
- reproduction in plants, including flower structure, wind and insect pollination, fertilisation, seed and fruit formation and dispersal, including quantitative investigation of some dispersal mechanisms
- the importance of plant reproduction through insect pollination in human food security

Inheritance, chromosomes, DNA and genes

- heredity as the process by which genetic information is transmitted from one generation to the next
- a simple model of chromosomes, genes and DNA in heredity, including the part played by Watson, Crick, Wilkins and Franklin in the development of the DNA model
- the variation between individuals of different species
- the variation between individuals within a species being continuous or discontinuous, to include measurement and graphical representation of variation
- the variation between species and between individuals of the same species leading to competition which can drive adaptation
- changes in the environment that leave some species less well adapted to compete successfully and reproduce, which might lead to extinction
- the use of gene banks to preserve hereditary material before a species becomes extinct.

Chemistry

Pupils should be taught about:

Pure and impure substances

- mixtures, including dissolving
- techniques for separating mixtures: chromatography, filtering, evaporation and distillation
- the identification of pure substances

The particulate nature of matter

- the properties of the different states of matter (solid, liquid and gas) in terms of particle kinetics, including gas pressure and diffusion
- changes of state in terms of particle kinetics and energy changes

Atoms, elements and compounds

- the nature of atoms, elements and compounds
- chemical symbols and formulae for elements and compounds
- conservation of mass in chemical and physical change

Chemical reactions

- chemical reactions as the rearrangement of atoms
- representing chemical reactions using formulae and using equations, including state symbols
- combustion, thermal decomposition, oxidation and displacement reactions

Energetics

- exothermic and endothermic chemical reactions (qualitative)

Acids, alkalis and neutralisation

- defining acids, bases and alkalis in terms of neutralisation reactions
- the pH scale for measuring acidity/alkalinity; and indicators
- reactions of acids with bases and metals to produce a salt, plus water

The Periodic Table

- the Periodic Table: periods and groups; metals and non-metals
- how patterns in reactions can be explained and predicted with reference to the Periodic Table
- the varying physical and chemical properties of different elements
- the chemical properties of metals and non-metals and metal and non-metal oxides with respect to acidity

Materials

- the order of metals and carbon in the reactivity series
- the use of carbon in obtaining metals from metal oxides
- ceramics, polymers and composites

Earth science

- the composition of the Earth and the atmosphere
- changes to the Earth's atmosphere since its formation
- the production of carbon dioxide by human activity and the impact on climate
- the efficacy of recycling.

Physics

Energy

Pupils should be taught about:

Changes and transfers

- examples of processes that cause change, with forces (work = force \times distance; levers and gears reducing force by increasing distance, changing motion, dropping an object, turning a dynamo to produce light); with matter (releasing a compressed spring, igniting fuel, putting hot and cool objects in contact, metabolism of food); with vibrations and waves (warming by radiation); and with electricity (completing an electrical circuit)

Energy and fuel

- calculations comparing ratings of appliances in kilowatts (kW) and amounts of energy from different foods (from labels)
- fuel, fuel sources and heating

Auditing change

- audit calculations using measures of change in the energy associated with elastic deformation, moving and/or vibrating objects, heating materials, and chemical changes involving fuels
- rates of change measured in kW.

Motion and forces

Pupils should be taught about:

Describing motion

- speed and the quantitative relationship between average speed, distance and time (speed = distance \div time)
- the representation of a journey on a distance-time graph
- relative motion: trains and cars passing one another; the movement of the sun, moon and Earth

Forces

- forces as pushes or pulls, arising from the interaction between two objects
- moment as the turning effect of a force: torque and rotational effects
- forces: associated with deforming objects; stretching and squashing – springs; with rubbing and friction between surfaces, with pushing things out of the way; resistance to motion of air and water
- forces measured in newtons, measurements of stretch or compression as force is changed
- Hooke's Law as a special case
- work done and energy changes on deformation
- gravity forces acting at a distance on Earth and in space

Pressure forces

- atmospheric pressure, decreases with increase of height as weight of air above decreases with height
- pressure in liquids, increasing with depth; upthrust effects, floating and sinking
- pressure measured by ratio of force over area – acting in all directions

Balanced forces

- opposing forces and equilibrium: weight held by stretched spring or supported on a compressed surface

Forces and motion

- forces being needed to cause objects to stop or start moving, or to change their speed or direction of motion
- change depending on direction of force and its size.

Waves

Pupils should be taught about:

Observed waves

- waves on water as undulations which travel through water with transverse motion; these waves can be reflected, and add or cancel – superposition

Sound waves

- frequencies of sound waves, measured in hertz (Hz); echoes, reflection and absorption of sound
- the speed of sound in air
- sound produced by vibrations of objects, in loud speakers, detected by their effects on microphone diaphragm and the ear drum; sound waves are longitudinal
- auditory range

Energy and waves

- sound waves carrying energy: for cleaning and physiotherapy by ultra-sound; for carrying energy and information for conversion to electrical signals by microphone

Light waves

- the similarities and differences between light and waves in matter
- light waves travelling through a vacuum; speed of light
- the transmission of light through materials: absorption, diffuse scattering and specular reflection
- the refraction of light, action of convex lens in focusing (qualitative) and the human eye
- light transferring energy, leading to chemical and electrical effects; photo-sensitive material in the retina and in cameras
- colour and the different frequencies of light, white light and prisms (qualitative only); differential colour effects in absorption and diffuse reflection.

Electricity and electromagnetism

Pupils should be taught about:

Current electricity

- electric current, measured in amperes, in circuits, series and parallel circuits and the domestic ring main
- current as flow of charge
- potential difference, measured in volts, battery and bulb ratings; resistance as the ratio of potential difference (p.d.) to current measured in ohms
- differences in resistance between conducting and insulating components

Static electricity

- separation of positive or negative charges when objects are rubbed together: transfer of electrons, forces between charged objects
- the idea of electric field, forces acting across the space between objects not in contact

Magnetism

- magnetic poles, attraction and repulsion
- magnetic fields by plotting with compass, representation by field lines
- Earth's magnetism, compass and navigation
- the magnetic effect of a current, electromagnets, D.C. motors.

Matter

Pupils should be taught about:

Physical changes

- conservation of material and of mass, and reversibility, in melting, freezing, evaporation, sublimation, condensation, dissolving
- similarities and differences between solids, liquids and gases
- brownian motion in gases
- diffusion in liquids and gases driven by differences in concentration
- the difference between chemical and physical changes

Particle model

- the differences in arrangements, in motion and in closeness of particles explaining changes of state, shape and density
- atoms and molecules as particles
- the anomaly of ice-water transition in terms of unique structure change

Energy in matter

- changes with temperature in motion and spacing of particles
- internal energy stored in materials.